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APPENDIX II.

[Vide answer to starred question No. 82 asked by Sri B. Bhima Rao at the meeting of the Legislative Council held on 7th January 1950, page 939 supra.]

Report on the Ramapadasagar Dam by the Committee of Consulting Engineers, London—August 5 and 6, 1947.

SRI N. GOVINDARAJA AYYANGAR, B.A., B.E.,
Chief Engineer (Special), Irrigation Branch,
Public Works Department,
Presidency of Madras,
Chepauk, Madras.

Dear Mr. Ayyangar,

The Committee of Consulting Engineers has given careful consideration to your questions relating to Ramapadasagar Dam and the Committee desires to submit herein below its considered and unanimous opinion on each of the questions. The questions will be numbered and quoted as stated by you, and each question will be followed by the Committee's answer.

" 1. Dr. Savage and Dr. Terzaghi have given their opinion in the matter of feasibility of the project in the following terms :—

Dr. Savage.—' Although the cofferdam and excavation features of this project are unusually difficult due to the character of materials to be encountered and the great depths to which excavations have to be unwatered there is no question in my mind about the feasibility of unwatering the foundations and maintaining them unwatered during the necessary periods of construction.''

Dr. Terzaghi.—' The excavation for the dam west of the Mahanandeswara Hill appears to be the most difficult part of the construction operations. The preceding discussion of the possibilities for making this excavation was based on the most unfavourable assumptions which can be made at the present state of our knowledge of the sub-soil conditions at the site of the excavation. It was assumed that the average coefficient of permeability of the sub-soil is as high as 0·1 c.m. per second and that the critical height of 4 : 1 slopes on the clay does not exceed 100 feet. In spite of these pessimistic assumptions the writer arrived at the conclusion that the project is feasible.'

The Committee is invited to place on record its view confirming the feasibility of the dam.''

The Committee is unanimous in its conclusion that despite unusually difficult river diversion and foundation excavation problems construction of the dam unquestionably is feasible.

" 2. The dam proper excluding the power-house, the canal heads, the locks, the foreshore acquisition had been estimated at Rs. 34 crores. The Committee is invited to offer its view :—

(*a*) whether the plans prepared are well thought out and not rapidly prepared,

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(b) whether the estimated cost is reasonable, so that the Madras Government can immediately after the Committee expresses its opinion undertake the execution of the following preliminary works which will commit an expenditure of about Rs. 5 crores, covering works as follows :—

(a) Camps, buildings, roads, etc.

(b) Railway line and sidings to dam site.

(c) Pontoon bridge.

(d) Water-supply and drainage to camps.

(e) Electricity.

(f) Telephone.

(g) Self-propelled floating drafts—purchase of—for conveying machinery, etc.

(h) Establishing a cement factory.

(i) Purchasing plants and machinery required for the workshop and for the early stages of preparation for the construction of the dam."

The Committee believes that the plans, as they will be modified following the joint discussions, will embody well considered and entirely adequate designs for the project. The Committee believes that the present estimated cost of Rs. 37 crores should be reviewed carefully to incorporate the modifications in design suggested by the Committee. On the basis of a hurriedly prepared cost estimate made by the International Engineering Company in Denver, Colorado, U.S.A., and transmitted by cablegram the revised estimate will be approximately Rs. 40 crores excluding interest during construction and contractors profit. As judged from known costs of other comparable projects the Committee believes this figure represents a reasonable estimate of cost for Ramapadasagar Dam, exclusive of the power plant, canal headworks, navigation locks and reservoir right of way.

"3. The Committee will be requested to say if the Madras Chief Engineer's view that the dam construction is beyond the scope of Indian contractors and should be entrusted to people who have successfully battled with such very difficult foundation and river diversion work and problems and built large and high dams is correct."

The Committee shares the belief of the Madras Chief Engineer that construction of this difficult project should be entrusted to fully competent and experienced contractors. It should not be entrusted to contractors who have not handled construction work of comparable magnitude and difficulties.

"4. The Committee will please advise the Madras Government if they will do well to engage the services of an Engineer with previous experience of high dam construction to watch their interests, even when the dam construction is entrusted to a firm of Approved Contractors and they have their own General Superintendent. The Committee will please suggest a panel of suitable names of such Engineers."

It is the unanimous opinion of the Committee that the Madras Government should employ a Construction Engineer or Engineers of broad experience on comparable construction work to advise the Chief Engineer who will represent Government in supervision of the work done by the Contracting Company. Each member of the Committee will submit by letter the names and experience statements of Construction Engineers whom they believe to be qualified for employment by the Madras Presidency.

" 5. The Committee is requested to advise if in the present conditions of manufacture and deliveries of machinery, the requisite heavy plant required for the project can be acquired and if in the course of a year or so, by which time the preliminaries such as construction of camps, provision of water-supply, etc., will have been got through, the position in regard to the purchase of plant will ease and the dam construction can be actively taken in hand from the end of 1948 or early in 1949. Will the Committee agree that the purchase of plant and machinery required by the contractors for the items of work these contractors are to do, should be left to them? "

The Committee believes that it would be difficult to purchase new construction plant and machinery during the coming year sufficient for starting active construction of the project by the end of 1948 or early in 1949. Also, it is believed questionable that Government should furnish such equipment if construction of the work is to be done under contract. The Committee agrees that the plant and machinery to be used by the contractors should be furnished by the contractors, and it is believed that such contractors will have the necessary plant and machinery or can supplement what they do have by purchase of new or used equipment sufficient for commencing work on the dam by the end of 1948 or early in 1949.

" 6. In view of the unusual difficulties in the matter of dam foundations, will the Committee advise that the commencement of canal construction to be taken up after the dam foundations are laid? "

The Committee entertains no doubts whatever about the feasibility of unwatering the foundations of the dam and maintaining them unwatered during the necessary periods of construction and therefore it is believed that commencement of canal construction should be undertaken at the most opportune time as determined by economic considerations. However, it may be found advisable to concentrate all available labour and equipment on the early and more difficult stages of dam construction.

" 7. *Location of the dam.*—Site plan showing the various sites examined, cross-sections of the sites, boring results, rock levels, etc., are furnished. The Committee is invited to express its views—

(a) Whether the dam is approximately on the right alignment.

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(*b*) Whether exploratory work done so far is sufficient to come to decision regarding building a concrete dam on the sub-surface rock.''

The Committee is in agreement with the project Engineers that the selected site for the dam is the best available site. Also, the Committee agrees that the exploratory work already completed is sufficient for determining that a concrete gravity dam can be constructed on the sub-surface rock and that such a dam will have adequate safety.

'' 8. The dam will be of the straight gravity type, on all concrete structure of height of about 420 feet in the deepest portion from top of foundation bed rock to top of roadway, with the spillway over the dam itself.

(i) The spillway sections will be controlled by 28 drumgates 135 feet long and 18 feet high with intermediate piers 15 feet thick.

(ii) The crest of the spillway section will be at elevation plus 180 and the F.R.L. is plus 198.

(iii) The dam is pierced by 80 sand sluices each 10 feet by 20 feet with their sills at plus 44 (low tail water level plus 43) to facilitate desilting of the reservoir.

(iv) The apron will be of the bucket type with invert level plus 74 and radius of invert 50 feet.

The Committee's views are invited on the following :—

(*a*) Whether the concrete dam has been so designed as to provide ample stability under the various conditions of loading to which it will be subjected.

(*b*) Whether the section of the dam proposed in the higher positions of the two abutments give the necessary stability against the lateral transfer of water load from the high central portion of the dam by twist action.

(*c*) Whether the position of spillways is suitable? Will the skew alignment of the left half of the dam induce currents which, during floods, will endanger the Polavaram town and camps and buildings on the right side?

(*d*) Whether the apron of the bucket type proposed is suitable? or what best possible protective works will the Committee suggest?

(*e*) Whether the number and size of sand vents with sill at plus 44 is adequate and suitable? The sand vents are designed to pass the normal flood flows of the river about 700,000 cusecs with a reservoir elevation of plus 135·00 ''.

During the Committee conferences certain changes in the present tentative designs of dam have been agreed upon as follows :—

(*a*) The drumgates on spillway will in the greater part be eliminated and a free overflow spillway with crest at full reservoir level (elevation plus 200 which may later be raised to plus 208) will be constructed. The vertical portion of spillway piers and the open spandrel bridge will be retained substantially as now designed and the roadway will be at about elevation plus 238.

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(*b*) The dam will be provided with 160 sand sluices each 14 feet wide by 20 feet high or alternatively 180 sand sluices each 12½ feet wide by 20 feet high, depending on stress and stability factors to be determined later. If the 14 feet width of sand sluice is adopted, the 160 sluices will be contained in the eighty 50-feet blocks as now shown on design drawings and no changes will be necessary in the location of power plants. If the 12½ feet width of sand sluice is adopted, 180 sluices will be required and these will be contained in ninety 50-feet blocks including ten additional blocks obtained by locating the power houses farther into the abutments. For either of these alternatives the sills of the sluices will be raised to the elevation of about plus 100 and they will discharge into the spillway bucket approximately as shown on the present design drawings.

The Committee is satisfied that the section of dam as finally determined by the International Engineering Company will provide adequate stability under the various conditions of loading to which it will be subjected. These stability factors will be carefully reviewed by the Committee when the studies are made available.

The lateral transfer of waterload from the high central portion of dam by twist action to the relatively thin high portions of dam at all four abutments can and should be eliminated if safe stresses and stability factors are exceeded. The elimination of such twist action can be effected by placing compressible material such as cork or celite on the compression side of all keys in one or more transverse contration joints of the dam adjacent to each of the abutment portions of it. In addition to this expedient the grouting of these particular joints should be deferred until the reservoir has been filled to three-fourth of the maximum head on the dam.

It is the impression of the Committee members that the spillway and sluiceway alignments are suitable but this question should be confirmed by hydraulic model tests of the completed project. Such a model should include model discharge facilities corresponding to all discharge facilities of the prototype including all of the sand sluices, overflow spillways and the power plants. The scale should be sufficiently large to provide a qualitative similitude between scour in the model and in the prototype using suitable fine sand for the model tests. It is probable that the protective embankments along the town of Polavaram and the construction camps and buildings can and will be rip-rapped with dumped rock that otherwise would be wasted elsewhere.

The free discharge bucket is considered to be adequate for protection of the foundations in deep portions of the river below the dam. However, it is proposed to protect the rock by concrete paving or otherwise wherever this is determined to be necessary after excavations expose rock conditions.

The number and size of sluices as outlined herein above should in the opinion of the Committee be sufficient to prevent any significant depletion by silting of the reservoir capacity beyond that inevitably silted in the reach of river channel extending for 20 to 25 miles immediately upstream from the dam.

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"9. *Life of the reservoir.*—A reservoir level of plus 135 is required to command the upland canals taking off above the dam. The flood season of the Godavari river is from about 15th June to 15th September when the waters will be heavily silt laden. During this period it is proposed to pass the entire flow of the river through the sand vents maintaining a maximum level of plus 135 which is called the diversion level. By about 15th September the sand sluices will be closed and the reservoir will begin to impound to about F.R.L. (full reservoir level). Thereafter the reservoir will be gradually depleted so as not to go below plus 135 on 1st July. On the basis of the above regulation, silt studies have been made and the useful life of the reservoir has been determined as the number of years taken to reduce the effective capacity of the reservoir to the limit required to meet the requirements of power and irrigation as per the project proposals. On these considerations the useful life of the reservoir is computed to be 487 years. The Committee is requested to advise—

(*a*) If on the basis of silt studies done so far the provision made of the disposal of the large volume of silt carried by the river is adequate and will prove effective?

(*b*) Whether it is necessary to provide another set of sluices at a higher level say at about plus 90 or so as to pass a flood flow of 1,000,000 cusecs with a reservoir level of plus 135, the additional sluices incidentally serving as a standby in the event of choking up of some of the low level sluices?

(*c*) What further arrangements are to be made to prolong the life of the reservoir."

The Committee believes that the proposed 160 sand sluices, each 14 feet wide and 20 feet high, or alternatively the 180 sluices, 12½ feet wide and 20 feet high, will provide adequate capacity for passing a large part of the volume of silt carried by the flood water of the river.

The single set or tier of sluices will suffice and the proposed larger number and size of the sluices will insure against choking of the sluices. Either of the presently proposed alternative sluice installations will provide about 1,250,000 cusecs capacity with the reservoir at the minimum elevation of plus 135.

The further arrangements necessary to prolong the life of the reservoir will include upstream storage which will offer very great possibilities. Careful consideration should be given to future development of upstream storage. Forestation is another desirable means of prolonging the life of reservoirs.

"10. The Committee's views are invited on the following: Whether the exploratory tests carried out on the soils met with will suffice to take definite decisions on—

(*a*) the arrangement of cofferdam suggested by Dr. Terzaghi, will the arrangement be suitable and feasible?

(*b*) whether the excavation of foundations in the cofferdams area according to the programme and sequence suggested by Dr. Terzaghi can be successfully done?

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(c) whether the excavated area can be kept unwatered during the construction period?"

(a) The general arrangement of cofferdam suggested by Dr. Terzaghi appears satisfactory. However, final decision on a number of details must await the completion of the supplemental investigations recommended by Dr. Terzaghi and the results of a further study of the construction programme and cofferdam layout now being made in Denver by an engineer with wide experience in cofferdam problems.

(b) The programme for the foundation excavation in the cofferdam area as suggested by Dr. Terzaghi in his revised report appears generally satisfactory but a final conclusion should await the results of the study referred to in (a).

(c) It is our opinion that, with well constructed cofferdams, adequate pumping equipment and direction of the work by a capable organization, the excavated area can be kept unwatered during the required construction period.

(Signed) S. O. HARPER.
(,,) MURDOCK MACDONALD.
(,,) J. L. SAVAGE.
(,,) KARL TERZAGHI.

6th August 1947.

APPENDIX III.

[Vide answer to starred question No. 90 asked by Sri R. Suryanarayana Rao at the meeting of the Legislative Council held on 7th January 1950, page 953 supra.]

Statement showing the names of sugar factories that were willing to produce power alcohol, their capacity and proposed output of power alcohol.

Name of the factory. (1)	Daily cane crushing capacity of the sugar factory. (Tons.) (2)	Quantity of power alcohol proposed to be manufactured. (Gallons.) (3)
1 East India Distilleries and Sugar Factories, Limited, Nellikuppam (South Arcot district)	**1,200**	**800,000 to 900,000**
2 Vizag Sugars and Refineries, Limited.	**125**	**. .**
3 Cauvery Sugars and Chemicals, Limited, Namakkal, Salem district	**600**	